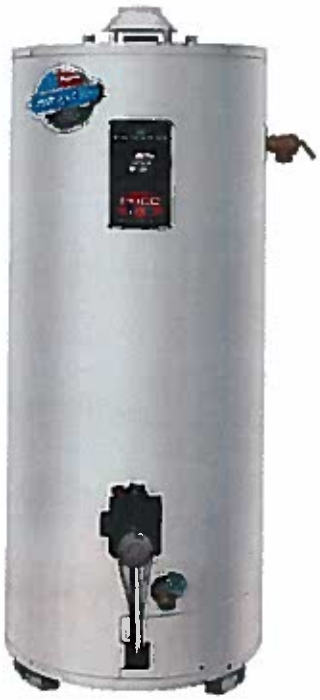
Question 1

An average hot water tank will hold 300.0 L of water needs to be kept at 65.0°C in order to kill any bacteria in the water. If you are filling a new tank with water at a temperature of 12.5°C, what mass of natural gas (methane) must be burned in a complete combustion reaction in order bring your tank up to code?



$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

Solution 1

(1) $\Delta H_x^\circ = \sum n\Delta H_{f(p)}^\circ - \sum n\Delta H_{f(r)}^\circ$

$= [(2)(-241.8) + (1)(-393.5)] - [(1)(-74.6) + 2(0)]$

$= (-877.1) - (-74.6)$

$= -802.5 \text{ kJ/mol of } CH_4$

(2) $q_{water} = mc\Delta T$

$= (300\,000)(4.18)(52.5)$

$= 65\,835\,000 \text{ J}$

or

$65\,835 \text{ kJ}$

(3) $\Delta H = n\Delta H_x$

$n = \dfrac{\Delta H}{\Delta H_x}$

$= \dfrac{-65\,835}{-802.5}$

$= 82.04\ldots \text{ mol}$

(4) $m = nM$

$= (82.04)(16.05)$

$= 1316.7 \text{ g}$

$\therefore \Delta H = -65\,835 \text{ kJ}$

Question 2

The Thermite reaction can be used to produce molten iron for welding railway tracks together.

$$Fe_2O_{3(s)} + 2\,Al_{(s)} \rightarrow Al_2O_{3(s)} + 2\,Fe_{(s)}$$ (5)

Calculate the amount of heat produced using 45.0 g of aluminum and excess iron (III) oxide.

Solution 2

① $\Delta H_x^\circ = [2(0) + (1)(-1675.7)] - [2(0) + (1)(-824.2)]$

$= -851.5\ kJ \rightarrow \Delta H_x^\circ = -425.75\ kJ/mol$

② $n_{Al} = \frac{m}{M}$

$= \frac{45.0}{26.98}$

$= 1.6679\ mol$

③ $\Delta H = n\Delta H_x$

$= (1.6679)(-425.75)$

$= -710.109\ kJ$

$= -7.10 \times 10^2\ kJ$

Question 3

It's 1976 and you are throwing a fondue party! You need to heat 800.0 mL of vegetable oil to 375°F (190.0°C) using an ethanol burner. Assuming a perfect transfer of heat from the burner into the oil, how much ethanol is required. Assume your kitchen is at SATP and the specific heat capacity of vegetable oil is 2.000 J/g.°C

Density of veg oil = 0.92 g/mL

$C_2H_5OH_{(l)} + 3O_2 \xrightarrow{\Delta} 2CO_{2(g)} + 3H_2O_{(g)}$

$(800.0\ mL)(0.92\ g/mL) = 736\ g$

Solution 3

① $q = mc\Delta T$
$= (736)(2.000)(165)$
$= 242\ 880\ J$

② $\therefore \Delta H = -242\ 880\ J$

③ $\Delta H_r^\circ = \sum n\Delta H_f^\circ (prod) - \sum n\Delta H_f^\circ (react)$
$= [(2)(-393.5) + (3)(-241.8)] - [(1)(-277.6) + 3(0)]$
$= (-1512.4) - (-277.6)$
$= -1234.8\ kJ/mol$

④ $\Delta H = n\Delta H_r$
$n = \frac{\Delta H}{\Delta H_r}$
$= \frac{-242.88\ kJ}{-1234.8\ kJ}$
$= 0.197\ mol$

⑤ $m = nM$
$= (0.197)(46.07)$
$= 9.08\ g$